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THE NASA SPONSORED HSCT PROPULSION STUDIES

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Objectives

One objective of the NASA-sponsored HSCT propulsion studies is to determine the potential benefits of alternative advanced technologies. These benefits should be explicitly expressed in terms of meeting either environmental acceptability or economic viability. The potential benefit information is used to screen alternative technology candidates to the most promising technologies that, if successfully developed, will enable the propulsion system to achieve high performance and low weight without unduly sacrificing favorable emissions and noise characteristics.

A second objective is the provision of key information to high-level decision makers--enabling them to make rational decisions concerning the technology program content. It will be necessary to pursue more than one concept/technology until experimental validity is convincingly demonstrated. Some technologies will likely fail to achieve their stated goals and timely program redirection depends upon far-sighted system studies to provide such information.

HSCT Propulsion Systems Studies

Objectives

1. *Determine potential benefits of alternative advanced technologies*
   - *-- Environmental acceptability*
   - *-- Economic viability*

2. *Provide key information enabling rational decisions concerning technology program content*

Major Propulsion Issues

The issues identified here reflect a global perspective that is important to keep in mind in our quest to identify the enabling technologies. The first issue, "What level of HSCT technology is required to attain competitiveness with anticipated subsonic technology," cannot be answered solely from a propulsion viewpoint. We need to forecast potential improvements in both subsonic and supersonic technology to properly assess the merits of HSR expenditures.

It would be very desirable to obtain a quantitative answer to issue 2. The price we pay for environmental acceptability should be expressed in economic terms.

While much of the needed propulsion technology can be unequivocally identified now, there remains a significant uncertainty about which engine cycle is preferable and, therefore, the required engine-specific technology.

Similarly, the preferable noise suppression strategy is presently uncertain. The noise suppression approach is intimately related to the engine cycle selection in this highly complex system.

HSCT Propulsion Systems Studies

Major Propulsion Issues

1. *What level of HSCT technology is required to attain competitiveness with anticipated subsonic technology ?*

2. *What price do we pay to achieve various levels of environmental acceptability ?*

3. *Which engine cycle is preferable ?*

   -- *Determines engine-specific technology*

4. *Which noise suppression strategy is preferable ?*

   -- *Front end approach (Tandem-fan, VCE, Flade, ...)*

   -- *Rear end approach (mixer-ejector nozzle, acoustic liners, TAS, ...)*

   -- *Hybrid*

Approach

There are a great multitude of propulsion system alternatives that need to be considered. Complicating a comprehensive evaluation of the many choices is the frequent lack of a credible database from which to formulate analytical models. Examples include the emission models for both the LPP and RQL type combustors. Until an experimental database is established, NO_x vs. performance tradeoffs will remain speculative.

Regardless of these shortcomings, the comparative evaluations need to be conducted on a system basis (a mission simulation) to avoid misleading analyzes. The general approach is to conduct complete mission analysis evaluations at the engine companies and NASA utilizing representative airframe and mission definitions supplied by the airframe manufacturers. Upon completion of the screening studies performed by the engine community, a recommended subset of propulsion systems are transmitted to the airframe manufacturers for a final selection that includes installation effects.

Since the emphasis should be on resolving first order issues, highly sophisticated analysis is neither needed nor appropriate except in cases where reliable simple models do not yet exist.

HSCT Propulsion Systems Studies

Approach

1. *Identify propulsion system alternatives*
   - *Components (inlets, nozzles, combustors, ...)*
   - *Engine types (TBE, VCE, MFTF, Flade, Tandem-fan, ...)*
   - *Technology levels (2000 EIS, 2005 EIS, 2010 EIS, ...)*

2. *Perform comparative evaluations on a system basis*
   - *Propulsion system performance and weight*
   - *Installation on a representative airframe*
   - *Mission simulation and evaluation criteria*

3. *Involve engine companies, airframe manufacturers, and NASA*

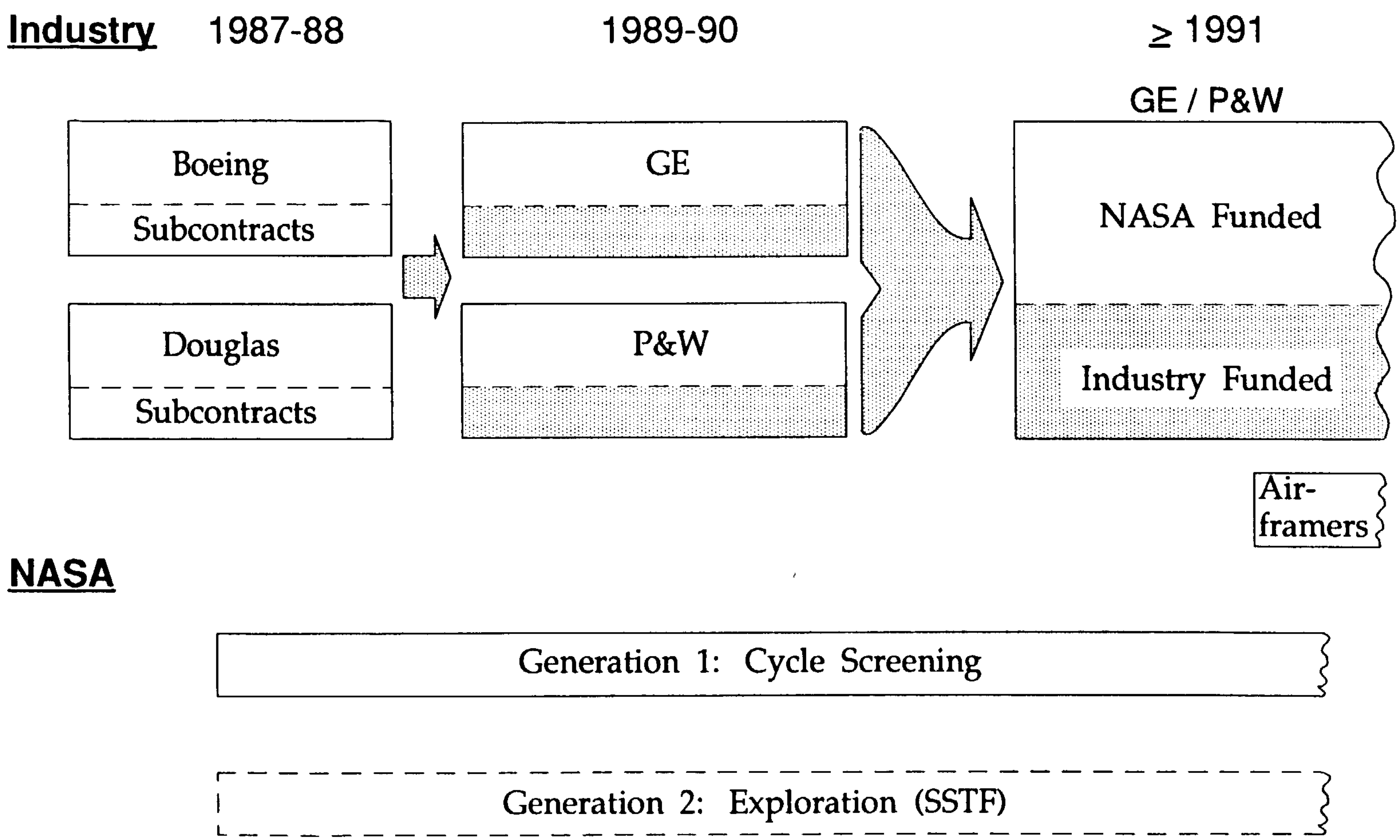
Studies Arrangement

The HSR industry propulsion studies have undergone a radical change in administration. They began life as subcontracts to the two airframe manufacturers. The arrangement was strengthened in 1989 when prime contracts were issued to both engine companies and they initiated IR&D and company funded internal support. Further strengthening occurred late in 1990 when General Electric and Pratt & Whitney initiated an unprecedented collaborative effort in recognition of the fact that a single combined approach is more effective than a parallel, but fragmented approach. In addition, airframe manufacturers are being funded to investigate propulsion-airframe installation options including inlet and nozzle concept screening.

NASA is also conducting in-house engine cycle screening studies to augment the industry studies. This effort is used mainly to help guide the industry effort by providing rapid first-order analyses that identify major drivers and sensitivities. Although not part of the HSR program, related studies are underway of potential second-generation HSCT powerplants such as the supersonic throughflow fan engine (SSTF).

HSR Propulsion System Studies

Studies Arrangement



HSR Propulsion System Studies Elements

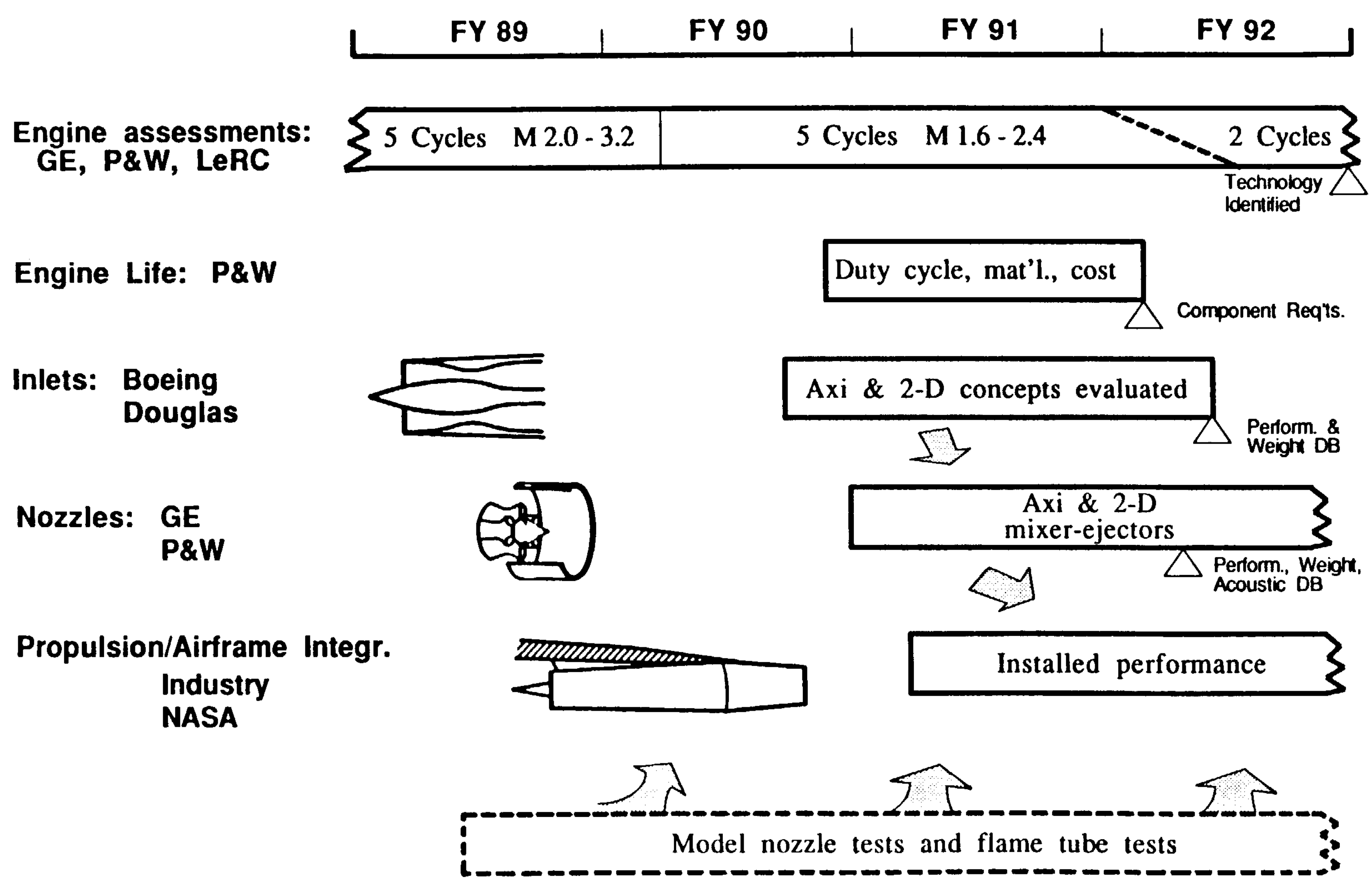
Until recently the propulsion studies effort was essentially addressing the issue of which engine cycle is most attractive. This investigation began over a broad range of flight speeds. Now it is focused almost exclusively at Mach 2.4 and there are five candidate cycles (engine types). Since a propulsion technology program cannot support a large multiplicity of engine types, the goal is to identify the two most promising cycles sometime in 1992. This selection will identify the engine-specific portion of the enabling technology program.

However, since the relative attractiveness of a given engine cycle also depends in large measure upon the inlet, nozzle, and airframe installation, a significant effort was begun in 1991 to establish an analytical database that characterizes the performance, weight, and acoustics of these important elements.

Since much of the effort to date relied on fighter engine design databases, a separate effort has been devoted to determine the impact of converting these designs to yield commercial engine life where the duty cycle is substantially different and leads to creep rather than cyclic fatigue failure.

All of this analytical information, together-with ongoing experimental model nozzle and combustion flame tube tests, will be integrated into the propulsion system technology decision process that occurs during 1992.

HSR PROPULSION SYSTEM STUDIES ELEMENTS



Propulsion Concept Status

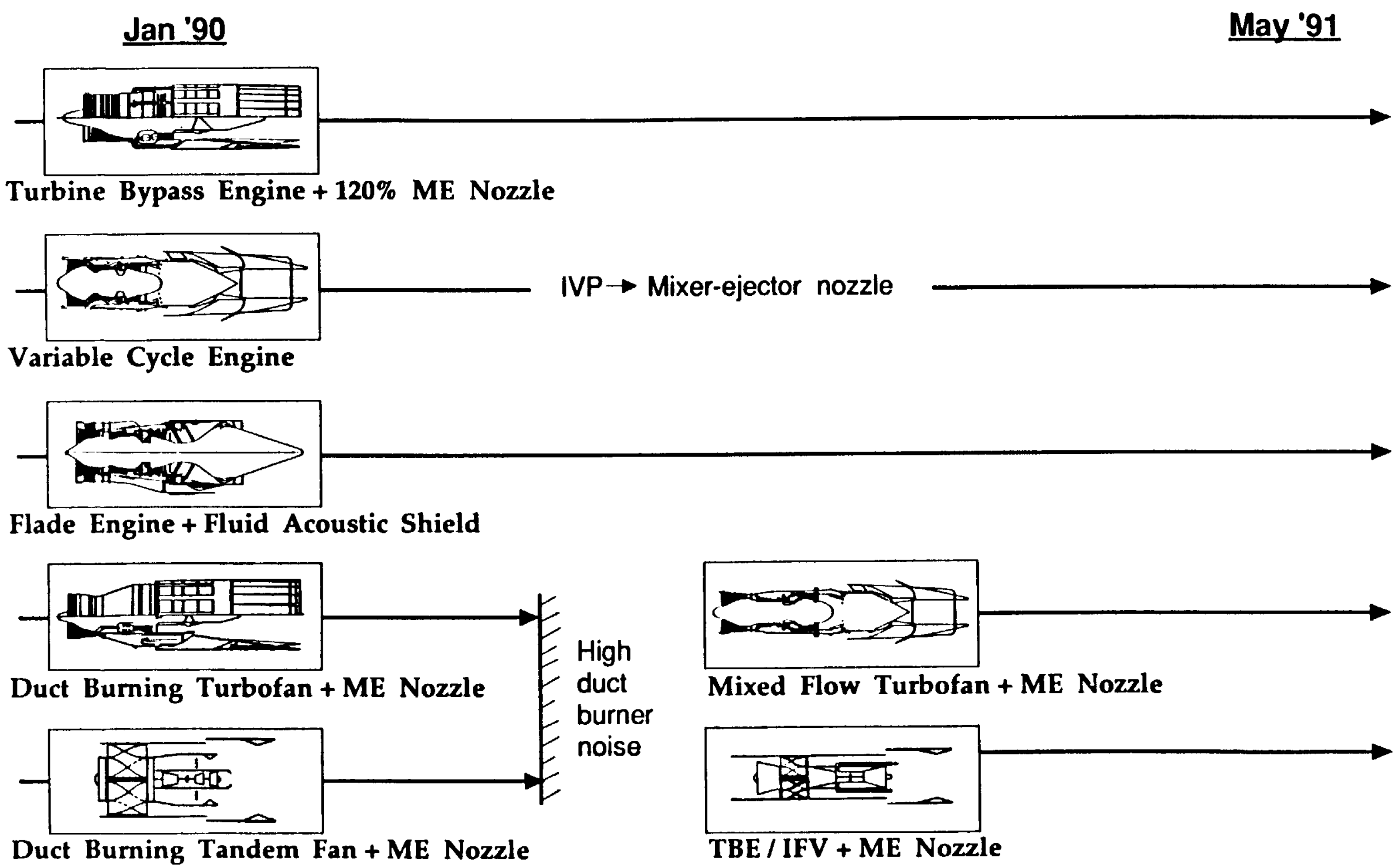
In early 1990, there were five candidate propulsion concepts being evaluated as depicted in the lefthand column. Only two of these concepts are being considered today unaltered--the turbine bypass engine (TBE) with a 120 percent airflow-augmented mixer-ejector (ME) nozzle and the "flade" engine with a fluid acoustic shield. The variable cycle engine survives but with a mixer-ejector nozzle instead of an inverted velocity profile (IVP) exhaust nozzle.

Both the duct burning turbofan (also known as the Variable Stream Control Engine) and the duct burning tandem fan have been dropped due to their excessively high burner noise. Replacing them are the mixed flow turbofan and the turbine bypass engine with an inlet flow valve (a tandem fan variant)--both with mixer-ejector nozzles.

Of the five current alternatives, only the TBE depends solely on an aft-end approach to achieve FAR36-3 noise compliance. All of the others use some form of the front-end, high-flow approach (variable cycle) together with a more modest aft-end acoustic suppression requirement.

HSR Propulsion System Studies

Propulsion Concept Status



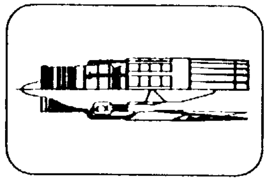
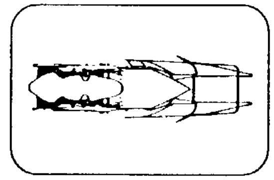
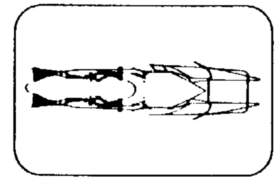
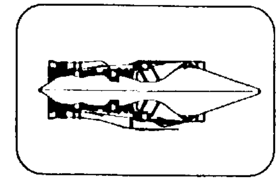
HSR Propulsion System Technologies

To illustrate the importance of identifying the most promising propulsion concept, this table summarizes some of the concept-specific technologies associated with each of the current contenders as well as generic technologies required by all of them.

Due to the rather high risk associated with many of these technologies, it may well be wise to pursue more than one concept in the technology development program to provide a reasonable level of confidence.

The following presentations provide a status review of the propulsion studies.

HSR PROPULSION SYSTEM TECHNOLOGIES

		TBE 	VCE 	TF 	Flade 
Generic	Low NOx Combustor	√	√	√	√
	CMC Materials	√	√	√	√
	IMC Nozzle Materials	√	√	√	√
	Commerical Life TM	√	√	√	√
	Inlet/Engine/Nozzle System incl. controls	√	√	√	√
Concept Specific	Mixer-Ejector Nozzle	√	√	√	
	Bypass Valving	√			
	Inlet Flow Valve	√ (IFV version)			
	Var. Bypass Injectors		√		√
	High-Flow Fan (Quiet ?)		√	√	√
	Flade Fan				√
	Fluid Acoustic Shield				√

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